Chapter 1

Introduction

Mobile devices like smartphone and tablet are turning out to be extremely dominant these days. The sales of mobile devices are expanding quickly. Annual smartphone sales surpassed sales of highlight mobile phones without precedent for 2014. Overall sales of mobile phones to end users totalled 968 million units in 2014, an expansion of 42.3 percent from 2013. Sales of Android phones passed the one billion development in 2015.

Mobile devices are turning out to be intense and simple to take since they are supplanting conventional PCs for both individual utilize and work reason. Cell phones are small computing gadget outfitted with different sensors and empower numerous helpful applications which were unlikely earlier. With the headway of portable equipment innovation, the improvement of versatile application have been changed from application that perform fundamental calculations to computationally escalated ones, going from progressive 3D amusements to augmented reality applications, speech recognition and image processing. Portable applications are getting to be energy hungry. Battery innovation has gotten to be one of the greatest snags for future development of versatile gadget because of certain reasons:

1. Mobile devices capability to devour energy far overtakes the battery’s aptitude to give it, as screens are receiving more honed, processors are receiving quicker, and gadgets are prepared with many sensors. Unfortunately, innovation advancement for batteries demonstrates that these constraints are now to stay, so that battery life will stay the essential jam for mobile devices.

2. Mobile devices are no more used just for voice message somewhat they are used for computation intensive applications like gaming, watching videos, web surfing, and etc. Therefore, these applications will devour more energy and reduce the battery life. Energy is an essential imperative for mobile devices. A review of 7,000 clients crosswide over 15 nations demonstrated that “75% of respondents said better battery life is the fundamental component they need”.

Keeping in mind the end goal is to give a fantastic client experience by taking care of the energy issue that has rapidly become the mobile industry’s greatest challenge.
Lately, mobile devices have seen the broad usage and have turned into the essential computing platforms for some clients. With the arrival of cloud computing, extensive quantities of servers are utilized in data centers. Energy effectiveness is an essential thought for designers of PCs including both mobile devices and servers.

1.1 MOBILE COMPUTING

Mobile computing is human—computer association by which one PC is required to be conveyed during ordinary utilization. Mobile Computing includes mobile software, mobile communication and mobile hardware. Mobile computing is the capacity to utilize computing ability without a pre—characterized area and association with a network to publish and subscribe to data. Mobile computing as a common term depicting capacity to utilize the innovation to wireless associate. It utilize centrally found data and application software through the utilization of little, convenient, wireless computing and communication gadgets.

The expression “Mobile computing” is utilized to portray the utilization of computing gadgets, which typically interact in some design with an essential information system while far from the typical, altered work environment. Mobile computing innovation empowers the mobile labour to make, process, access, store and conveys data without being obliged to a separate area. By developing the span of an association’s settled data framework, mobile computing empowers collaboration with hierarchical workforce that was already detached. Mobile computing is the control for making a data administration stage, which is free from spatial and temporal limitations. The opportunity from these limitations permits it’s clients to get and handle desired data from any place in the space. The condition of the client is static or portable which does not influence the data administration capacity of the mobile platform being compelled to a single area. To encourage the information management exercises, clients can convey Personal Digital Assistant (PDA), mobile phones, laptop and so on. At present, the present innovation just gives constrained exchange handling capacities, but soon such amenities will be accessible on every mobile phone. This control permits us to characterize a connectivity mode, which will term as Mobile Connectivity. The portable network between two hubs exists in the event that they are constantly associated with wireless canal and can use the canal without creature subjected to temporal and spatial imperatives.

1.2 EVOLUTION OF MOBILE PHONES

In 1947 AT&T acquainted Mobile Telephone Service (MTS) with numerous towns in America. In 1973, Motorola made the first handheld mobile. Martin Cooper, who was
a Motorola scientist at that time, made the world’s first mobile phone call. The model
needed to charge for 10 hours and just had a 30 minutes talk time. The 2G cellular
telephone framework was generally conveyed in 1990s. With expanding request on data
communication, 2G innovation was supplanted by 3G innovation in cellular telephone
from 2001. Presently, equipment makers and transporters give careful consideration on
offering 4G and LTE advances to suit bandwidth-intensive applications.

1.3 CLOUD COMPUTING ENVIRONMENT FOR DEVELOPMENT

Cloud computing is another style of computing that gives adaptability of resources and
services offered (Yeo et al., 2010; Lin et al., 2009). Cloud computing is a creative
energy of (Kleinrock, 2005) one of the researchers at Advance Research Project Agency
(ARPA). In 1969 he said, “Starting now, PC systems are still in their earliest stages,
however as they grow up and get to be refined. We will most likely see the spread
of ‘PC utilities’ which is similar to present electric and phone utilities that will service
singular homes and workplaces across the country”. Cloud computing paradigm is a
significant stride towards this fantasy. Ordinarily, the web is spoken to utilizing cloud
to signify some other stuff that makes the system as portrayed in Figure 1.1.

Cloud computing is a paradigm that permits to get the application lived at an area
other than client’s PC and offers its capacities as a service (Hayes, 2008). Cloud services
empower the clients to get the IT assets whenever and from anyplace utilizing various
gadgets like laptops, PCs and Smartphones and so forth. Accessibility of information
in cloud permits the client to get to the information whenever needed.

Cloud computing paradigm gives versatile and virtualized assets. Virtualization is
helpful for asset sharing and typical use of assets. Since, clients are not keeping up the
IT assets. Thus they are allowed to focus on business as opposed to on IT, that is cared
for specific and qualified manpower of cloud provider. Cost saving, dynamic versatility
and high accessibility are probably a huge points of interest of cloud computing. Al-
though, this is moderately another worldview which has risen up out of a portion of the
current innovations, for example, distributed, grid and virtualization etc. utilizes them
vigorously.

Computing has seen changes, yet it has changed radically in a most recent couple
decades (Voas and Zhang, 2009). The improvement in computing can be arranged as
portrayed below:

- Phase 1: General reason programmable PC were utilized particularly for calcula-
tion.
- Phase 2: Non-adaptable analog PCs were utilized. They eased back and to be
  wired physically.
Figure 1.1 Internet Notation of Cloud.
Table 1.1 Difference in Mainframe and Cloud Computing

<table>
<thead>
<tr>
<th></th>
<th>Mainframe</th>
<th>Cloud Computing</th>
</tr>
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<tbody>
<tr>
<td>Computing Power</td>
<td>Have limited computing power</td>
<td>Practically unending computing power</td>
</tr>
<tr>
<td>User Interface</td>
<td>Utilizes moronic terminal</td>
<td>Have intense PC as terminal which can perform computation</td>
</tr>
<tr>
<td>Scalability</td>
<td>On interest scalability isn’t available</td>
<td>On request simple scalability</td>
</tr>
</tbody>
</table>

- Phase 3: Digital PCs were utilized to tackle complex issues. These PCs were quick in contrast with simple.
- Phase 4: Users had moronic terminal and sharing a capable centralized computer.
- Phase 5: Users had autonomous PCs with computing usefulness like processing, memory and capacity. Due to their individual computing abilities, they don’t rely upon the centralized server PC for computing.
- Phase 6: PCs were associated with different PCs and servers to form a network so that the information sharing can occur and performance can be enhanced.
- Phase 7: Local system were associated with the worldwide system to form the Internet for worldwide sharing.
- Phase 8: Grid computing permitted the sharing of computing energy and capacity over distributed computing system.
- Phase 9: Computing to wind up the item and shared assets are given on the web. Resources are adaptable to provide the increased demand. Looking at these ideal models, it creates the impression that we have come back to mainframe computing as cloud computing seems like to be utilizing mainframe. However the cloud paradigm is fundamentally unique in relation to the mainframe and same has been portrayed in Table 1.1.

1.4 DEFINITIONS OF CLOUD COMPUTING

Various specialists have diverse perspectives to characterize cloud computing and define them according to their observation in this way, different definitions exist today, some of them are portrayed underneath:
(Buyya et al., 2008) characterized the cloud as a sort of parallel and distributed framework comprising of an accumulation of interconnected and virtualized PCs that are progressively provisioned and offered as one or more brought together computing resources in light of service-level agreements set up through an arrangement between the service provider and consumers. Be that as it may, generally acknowledged definition by cloud security organization together (Mell and Grance, 2010) given by National Institute of Standards and Technology (NIST), characterizes cloud computing as a model for empowering ubiquitous, helpful, on-interest network access to a common pool of configurable computing resources (e.g., servers, networks, applications, services and storage) that can be quickly provisioned and discharged with insignificant management exertion or service supplier communication. This cloud model is made out of five vital characteristics, three service models, and four deployment models. The complete definition of NIST has been represented in Figure 1.2.

To impose this definition changes are required from the equipment level itself. In common systems, the need was distinctive thus gadgets utilized were unique about that of cloud computing in this way and it utilizes the diverse segments. To get out of the cloud computing, it is vital that suitable sort of equipment part ought to be utilized by both the cloud client and the provider.

### 1.5 CLOUD COMPUTING COMPONENTS

To give the ubiquitous access, appropriate types of the part are expected to encourage the straightforward entry and to give important security in the cloud environment. The fundamental components of cloud computing are client, distributed server and data center.
1.5.1 CLIENT

A client is a gadget that is utilized to get to the cloud. A wide assortment of gadgets is accessible that empowers the client to interface with the cloud. Choice of customer gadgets relies on the client’s need such as access to the database, blog or video conferencing and so on. A solitary or the combinational of customer gadgets can be utilized to get to the cloud. Each of these gadgets is having their own merits and demerits. These gadgets are required to be arranged in a way so that they ought to give the accessability with ease and greatest security. Customers that can be utilized for accessability are a thin client, fat client and advanced smartphones. Thin clients are those PCs which don’t have their particular hard disk CD/DVD ROM having restricted processing capacities. They depend on the server for larger part of the computational task. Another class of customers is a fat client which are self-governing PC and have their quick preparing and capacity. Fat customers are utilized by the clients who need to utilize both the system and additionally the cloud. Such clients are utilizing their system for sensitive information while the cloud is used for all other work. A thin client is helpful in situations where clients are getting to the cloud to utilize it as a service. In this, getting to there is a high level of security for the information is put away in the cloud. Mobile users are the third class of client which changes from a laptop to advanced smartphones. Mobile devices give ease of entry and empower the clients to access the cloud from anyplace. Cellular telephone like iPhone and Blackberry can be utilized as a customer to get to the cloud. Laptops are extremely reasonable for mobile accessability aside from giving portability which gives accessability and security like that of the desktops. To encourage the correspondence between the accessing gadgets and cloud, client software is utilized. In larger part of the cases, web program is utilized as client software to access the cloud. A portion of the cloud providers is also giving the little establishment software that is required to be introduced on the client’s PC to access the cloud.

1.5.2 DISTRIBUTED SERVER

In cloud computing environment, customers demand services from the cloud server; while, servers are utilized to serve the client demand. In this paradigm, servers are not situated at the same spot, rather they are scattered at various geographical areas. In any case, they appear to the client as contiguous. The load is dispersed to the proper sort of server of that location. This methodology is embraced by a portion of the major cloud providers like Amazon (http://www.amazon.com). In multi-area server, failure of one server does not paralyze the whole operation rather the heap is moved to other server of the same or distinctive area. Thus, it enhances the reliability and ruins intrusion of services if the case of failure.
1.5.3 DATA CENTER

Data Centers (DC) are the key segments in a cloud. Data centers encourage adaptable cloud services. In the cloud, client’s information are put away in the data center, situated at various areas (McFedries, 2008). A data center comprises of Physical Host (PH), storage capacity and high-performance network infrastructure (Voith et al., 2012). These assets are overseen by cloud provider. Subsequently, there is no upfront cost and clients are paying according to the use (Furht, 2010; Zhu, 2010). To give the services to the client these data centers must have high accessibility. A portion of the data center gives 99.99% availability (ANSI/TIA, 2005).

Servers can access the information kept in vast scale data centers comprising of a huge number of PC and storage connected to form a network. Some public cloud providers have received a two-tier architecture to advance data center cost and service conveyance (Greenberg et al., 2008). To give the isolation of services, it takes after various levelled outline having access layer, accumulation and center layer. Data center compute the workload submitted and the client expects the Local Area Network (LAN) like experience. According to the record cloud report 2011, 79% workloads provided are for conventional based framework, while just 21% are data center based. According to the Cisco global index data center offer will reach to 57%, while that of the customary data center will be diminished to 43% (Source: Cisco, 2011). Cisco is idealistic in the development of data center. Correlation on the development of traditional and cloud data center is shown in Figure 1.3 (Source: Cisco, 2011).

Figure 1.3 demonstrates the development of data center from the year 2010 to 2015, while the year 2013 will be the breaking point.
1.5.4 KEY ATTRIBUTES OF CLOUD

Cloud computing is not quite the same as the conventional computing from numerous points of view. The key properties and their capacities in the cloud are portrayed in Table 1.2 (Jens, 2008).

1.6 CHARACTERISTICS OF CLOUD COMPUTING

To qualify an innovation as distributed computing, NIST gives five crucial attributes as follows

1.6.1 ON DEMAND SELF SERVICES

A customer can singularly provide computing capacities like network storage and server time, as required naturally without needing human communication by every service provider.

1.6.2 EXPANSIVE NETWORK ACCESS

Capacities are accessible through the net and access over a regular methodology that advance use by diverse thick or thin customer platforms (e.g., tablets, mobile devices, laptops and workstations).

1.6.3 RESOURCE POOLING

Cloud computing relies on distributed model where resources are appropriated all through the data center. If there arises an extreme need of resources, they can be pooled with various physical and virtual assets to serve different consumers. These resources are allocated and reallocated by demand. Locations, from where resources are pooled are not known to the consumer, user can just indicate area at the more elevated amount of notion (e.g. data center, nation or state). Examples of assets that can be pooled incorporate capacity, memory, processing, and network bandwidth.

1.6.4 RAPID ELASTICITY

Competencies could be flexibly supplied and settled at times subsequently proportional either internally or externally with request. To the user, the abilities accessible for providing often seem to be boundless and could be taken at all time.

1.6.5 MEASURED SERVICE

Cloud systems spontaneously control and enhance assets by influencing a metering ability at some level of notion suitable to the kind of service such as processing, band-
**Table 1.2 Key Attributes of Cloud Services**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offsite, third party provider</td>
<td>In cloud computing, it is expected that services are given by the third party and assets are overseen off-site. However, alternative of in-house conveyance also exists.</td>
</tr>
<tr>
<td>Accessed via the Internet</td>
<td>Services are accessed using standard-based network. Getting to technique is sufficiently secure and gives nature of service.</td>
</tr>
<tr>
<td>Minimal or No IT skill required</td>
<td>Simplified prerequisite determination encourages self-service demand and provisioning of assets progressively arranged. Requesting for close ongoing deployment, dynamic and fine-grained scaling.</td>
</tr>
<tr>
<td>provisioning</td>
<td></td>
</tr>
<tr>
<td>Pricing</td>
<td>Instead of forthright cost, it is pay according to utilization models. In cloud computing bill is changing according to the utilization, rather than fixed.</td>
</tr>
<tr>
<td>Client Interface</td>
<td>To access, the cloud for the most part browser is utilized. In few cases, exclusive software is likewise given to access the cloud resources.</td>
</tr>
<tr>
<td>System Interface</td>
<td>System interface depends on web services API’s giving standard framework.</td>
</tr>
<tr>
<td>Shared Resources</td>
<td>Same resources are shared among everyone of the clients. In any case, assets are modified according to the need of the users.</td>
</tr>
</tbody>
</table>
width, active user accounts and storage. Utilization of assets could be observed, measured and stated by providing clarity for the consumer and the provider.

1.7 CLOUD DEPLOYMENT MODEL

Clouds can likewise be arranged based on the core infrastructure deployment model as Private, Public, Community, or Hybrid clouds (Mell and Grance, 2010; Hurwitz et. al., 2010; Venkatachalam and Franz, 2005; Mather et. al., 2009). The unique infrastructure deployment models are different with their particular attributes. The qualities to portray the deployment models are (i) who claims the infrastructure (ii) who deals with the infrastructure (iii) where is the infrastructure found (iv) who has entry to the cloud services.

1.7.1 PRIVATE CLOUD

The cloud system is worked only inside a private connection and overseen by the organization or a third party in any case whether its found introduced or off premise. The inspiration to set up the private cloud inside an association has a few viewpoints. Initially, to boost and improve the usage of current internal resources. Second, security worries including information security and hope likewise create Private Cloud a possibility for some organizations. Third, information exchange price from neighbourhood IT foundation to a Public Cloud is still rather impressive. Fourth, associations dependably need full control through mission-basic exercises that live behind their firewalls. Finally, scholastics regularly fabricate private cloud for research and educating purposes.

1.7.2 COMMUNITY CLOUD

A few associations together develop and have the same cloud framework along with approaches, prerequisites, concerns and values. The cloud group frames into a level of financial adaptability and majority rule balance. The cloud base could be facilitated by a outside seller or inside one of the associations in the group.

1.7.3 PUBLIC CLOUD

Public cloud computing depends on large scale offerings to the overall population. The Infrastructure is situated on the premises of the supplier, who additionally claims and deals with the cloud Infrastructure. Public cloud clients are thought to be untrusted which implies they are not attached to the organization as representatives and that the client has no authoritative concurrences with the provider. Numerous mainstream
cloud services are public clouds including S3, Google AppEngine, Amazon EC2 and Force.com.

1.7.4 HYBRID CLOUD

The cloud foundation is a mix of two or more clouds (private, public, or community) that endure elements, however, are bound together by institutionalized or restrictive technology that empowers information and application transportability (e.g., cloud blasting for load balancing between clouds). Organizations utilize the hybrid cloud model remembering the real objective to upgrade their assets to build their center skills by margining out peripheral business capacities onto the cloud while controlling center activities on-reason through a private cloud.

As you can visualize, every service and deployment model fits some plans of action superior to anything others. Expansive organizations will profit by the private cloud, though littler organizations will probably be a public cloud. As cloud computing keeps on developing, organizations will keep on shifting forward and backward through these four unique ideal models.

1.8 CLOUD SERVICE MODELS

To provide the need of clients, cloud is offering various types of services. Client might get to the framework, platform or the application from the cloud as a service and paying for what has been utilized. Some of these services are offered by the cloud supplier though rests of them are worked with the cloud client, as exhibited in Figure 1.4. Cloud services have been arranged by NIST into Software as a Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS). Each of them has been characterized in the upcoming sub-segment.

1.8.1 INFRASTRUCTURE AS A SERVICE (IaaS)

The IaaS service model is the most reduced service model in the innovation stack, offering PC Infrastructure as a service, for example, crude information storage, preparing power and network limit. The consumer can utilize IaaS based service offerings to send his/her operating systems and applications, offering a more extensive assortment of potential arrangement outcomes for a customer than the PaaS and SaaS models. The user does not oversee or control the hidden cloud base, however, has control through storage, deployed applications, operating systems and perhaps constrained control of select networking parts (e.g., host firewalls) (Mell and Grance, 2010).

A remarkable business item that offers provisions at this level is the Amazon Elastic Compute Cloud or Amazon EC2. This provision gives the client full control over the
computing resources till he/she is paid. This doesn't imply that the cloud client has control over the hidden cloud fabric; however that he/she has control over a virtual machine, or a set of resources, running on top of the Cloud structure controlled by the cloud provider. In this setting, the cloud client is free then to construct their virtual machines with whichever arrangements he/she gets fit. This can be seen as the layer where the level of flexibility of the client is the most astounding. At this layer, the Cloud client still must be worried about keeping up the product he/she introduces to the resources hired to the cloud provider.

1.8.2 PLATFORM AS A SERVICE (PaaS)

The PaaS model offers the services such as operation and advancement platforms to the consumer. The consumers can utilize the platform to create and run their own applications, strengthened by a cloud-based foundation. The customer does not oversee or control the basic cloud foundation including operating systems, network, servers or memory capacity, yet has control through the conveyed apps and potentially application facilitating environment settings. A great case of PaaS is a virtual machine image containing an arrangement of software services (for instance, a Linux conveyance, a Web server and a programming environment such as (PHP) with a specific end goal to offer a web development environment for the Cloud developer).

Some business case from related organizations in the IT field is as of now accessible. From the Microsoft, we have the Windows Azure Platform, while Google offers the Google App Engine. The cloud designer can utilize these platforms to streamline its usage procedure by depending on the arrangement of predefined devices provided by them. In spite of the fact that these stages can give an large measure of adaptability, the
Table 1.3 Cloud Services and Cloud Providers

<table>
<thead>
<tr>
<th>Cloud Service Models</th>
<th>Cloud Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software as a Service(SaaS)</td>
<td>Salesforce.com, Microsoft office 365, workday</td>
</tr>
<tr>
<td>Platform as a Service(PaaS)</td>
<td>Force.com, Google App. Engine</td>
</tr>
<tr>
<td>Infrastructure as a Service(IaaS)</td>
<td>Amazon EC2, GoGrid, iCloud and Microsoft Azure DC</td>
</tr>
</tbody>
</table>

Impediment at this level is that the developer is compelled by the functionalities offered through these platforms.

1.8.3 SOFTWARE AS A SERVICE (SaaS)

The SaaS model offers the services such as applications to the shopper, utilizing institutionalized interfaces. The services keep running on top of a cloud framework, which is undetectable for the consumer. The cloud provider is in charge of the management of the application, operating systems and supporting base. The customer can just control a portion of the client particular to application design settings. A pioneer in the business of SaaS is Salesforce.com, who is setting forth multitenant arrangements in the arena of Customer Relationship Management (CRM) meanwhile before the presence of the idea of SaaS with regards to cloud computing.

A later case of this kind of arrangement is the email service offered by Google, i.e., GMail through its Google App Engine. In these circumstances, the Cloud client is just inspired by getting the most out of the application given by the Cloud. At this level the cloud client is definitely not seen as a developer any longer, he/she is a primary client of the arrangements offered by cloud developers.

Table 1.3, List of the cloud services provided by a portion of the cloud providers.

1.9 MOBILE CLOUD COMPUTING

The Mobile Cloud Computing (MCC) Forum characterizes MCC as follows (Mccforum, 2013): Mobile Cloud Computing at its modest alludes to a framework where both the information storing and processing happens outside the mobile device. Mobile cloud applications transfer the computing control and data storage far from mobile device bringing applications and mobile computing to not just smartphone users but to a much broader range of mobile subscribers.
On the other hand, (Othman et. al., 2014) MCC as a combination of cloud computing technology with mobile devices makes the mobile devices complete as far as computational power, storage, energy, memory and context awareness.

1.9.1 ARCHITECTURE OF MCC

From the idea of MCC, the general architecture of MCC can be appeared in Figure 1.5 (Dinh et. al., 2014). In Figure 1.5, mobile gadgets are associated with the mobile networks through base stations (e.g., Base Transceiver Station (BTS), access point, or satellite) that set up and control the associations (air links) and useful interfaces between the networks and mobile devices. Mobile clients requests and data (e.g., ID and area) are transmitted to the central processors that are associated with servers giving portable network services. Here, portable network operators can provide services to mobile users as AAA (for authorization, authentication and accounting) taking into account the Home Agent (HA) and subscribers information away in databases. After that, the subscribers request are conveyed to a cloud through the Internet. In the cloud, cloud controllers process the request to give mobile users the relating cloud services. These services are produced with the ideas of virtualization, service-oriented architecture and utility computing (e.g., application, web and database servers).
1.10 STATE OF THE ART IN ENERGY-EFFICIENT COMPUTING SYSTEMS

A vast volume of research has been done in the territory of power and energy-efficient asset management in computing frameworks. As power and energy management procedures are firmly associated, in this part they are alluded to as power management. As appeared in Figure 1.6, at the abnormal state, power management methods can be isolated into static and dynamic. From the hardware perspective, Static Power Management (SPM) contains all the streamlining strategies that are connected at the design time at the circuit, logic, architectural, what’s more, framework levels (Mather et. al., 2009; Venkatachalam and Franz, 2005). The Circuit level improvement is centered around the lessening of the exchanging action power of individual logic gates and transistor level combinational circuits by the use of complex gate design and transistor sizing. The enhancement at the logic level is gone for the switching activity power of logic level combinational and sequential circuits. Architecture level techniques incorporate the examination of framework design and ensuing consolidation of power streamlining procedures into it. As it were, this sort of streamlining alludes to the procedure of proficient mapping of an abnormal state issue determination onto an register-transfer level plan.

Aside from the optimization of the hardware level framework design, it is critical to deliberately consider the usage of projects that are to be executed on the framework. Indeed, even with splendidly designed hardware, poor software design can prompt to emotional execution and power misfortunes. In any case, it is unreasonable or difficult to analyze utilization brought about by substantial projects at the operator level, as not
just the procedures of code era and compilation, additionally the request of directions can have an effect on power utilization (Jens, 2008; Su et al., 1994; Tiwari et al., 1993). In this manner, circuitous estimation techniques can be connected. For instance, it has been demonstrated that speedier code quite often suggests bring down vitality utilization (Ong and Yan, 1994; Tiwari et al., 1994). Since non specific strategies for integrating optimal algorithms are not right now accessible, algorithm analysis is a critical research area.

This part concentrates on Dynamic Power Management (DPM) procedures that incorporate techniques and methodologies for runtime adjustment of the framework conduct as indicated by the current resource necessities then again some other element normal for the framework state. A noteworthy presumption empowering DPM is that frameworks encounter variable workloads amid their operation permitting the dynamic change of power states as per the present execution prerequisites. Another regularly made presumption is that the workload can be anticipated to a specific degree, which empowers the surmising of future framework states and taking the suitable activities.

As appeared in Figure 1.6, DPM systems can be recognized by the level at which they are connected: hardware or software. Hardware DPM fluctuates for various hardware parts, yet as a rule can be delegated Dynamic Performance Scaling (DPS), for example, Dynamic Voltage and Frequency Scaling (DVFS), and partial or complete Dynamic Component Deactivation (DCD) amid periods of dormancy. Interestingly, software DPM strategies use an interface to the framework’s power management abilities and as indicated by their arrangements apply hardware DPM.

1.10.1 HARDWARE AND FIRMWARE LEVEL

As appeared in Figure 1.6, DPM techniques connected at the hardware and firmware level can be extensively separated into two classes: Dynamic Component Deactivation (DCD) and Dynamic Performance Scaling (DPS). DCD strategies are based upon clock gating of parts of an electronic segment or complete disabling the segments amid times of inertia. Interestingly, rather than totally deactivating framework parts, DPS methods dynamically adjust the performance of the parts as per the ongoing requests.

1.10.2 ADVANCED CONFIGURATION AND POWER INTERFACE

Numerous DPM algorithms, such as timeout-based and additionally other prescient and stochastic strategies, can be executed in hardware as a part of an electronic circuit. In any case, a hardware usage exceedingly entangles the adjustment and reconfiguration of the strategies. Hence, there are strong reasons to move the implementation to the software level. In 1996 to address this issue, Intel, Microsoft, and Toshiba have distributed the main variant of the Advanced Configuration and Power Interface (ACPI) specifi-
cation an open standard characterizing a brought together OS-centric gadget arrangement and power management interface. As opposed to past Basic Input/Output System (BIOS) focal, firmware-based, and platform-specific power management frameworks, ACPI depicts platform-independent interfaces for hardware revelation, setup, power management, and monitoring.

1.10.3 OPERATING SYSTEM LEVEL

This segment talks about research works that deal with power-efficient resource management in computing frameworks at the OS level. Specifically, the proposed arrangements are characterized with respect to the accompanying attributes:

1. Application adaption — whether the system requires modifications of the application level software to take advantage of power management.

2. System resources — whether the system focuses on optimizing a single system resource, such as the CPU; or multiple system resources.

3. Target systems — whether the approach is general and can be applied to an arbitrary system; or specializes on mobile devices or server hardware.

4. Goal — whether the system minimizes power/energy consumption under performance constraints; or manages a power budget, also referred to as power capping.

5. Power saving techniques — DPS techniques, such as DVFS; DCD techniques; or just making the resources idle without explicit changes in hardware power states, which is referred to as resource throttling.

6. Workload — whether the system is transparent to the application workload; or focuses on particular types of applications, such as service or HPC applications.

1.10.4 VIRTUALIZATION LEVEL

An innovation that can enhance the use of server resources, and hence, lessen power consumption, is virtualization of computing resources. Virtualization presents an abstraction layer between an OS and hardware. Physical resources can be part into a number of logical cuts called Virtual Machines (VMs). Each VM can oblige a singular OS making for the client a perspective of a devoted physical resources and guaranteeing the execution and failure confinement between VMs sharing a solitary physical machine.

Virtualization permits one to make a few VMs on a physical server; and consequently, diminish the measure of hardware being used and enhance the usage of resources. The idea begun with the IBM mainframe OSes of the 1960s, however was
marketed for x86-compatible PCs just in the 1990s. A few business organizations and open source projects now offer software packages to empower the move to virtual processing. Intel Corporation and AMD have likewise manufactured exclusive virtualization improvements to the x86 instruction set to bolster hardware-assisted virtualization.

Among the advantages of virtualization are enhanced fault and performance detachment between applications having the same process hub (a VM is seen as a committed resource to the client); the capacity to generally effectively move VMs from one physical host to another utilizing live or disconnected relocation; and support for hardware and software heterogeneity. The capacity to move VMs at run-time empowers the method of energy-efficient dynamic VM solidification connected at the data center level.

The multiplication of virtualization can possibly drive more extensive reception of the idea of terminal servers and thin clients, which have additionally been utilized as a part of the Green IT rehearses. In this idea, numerous clients associate with a focal server over the network utilizing thin clients. While all the processing required by the clients is done on the mutual physical server, from the client point of view, the association is like that with a devoted computing resource. With respect to energy utilization, the benefit of thin clients is that they expend fundamentally less vitality contrasted and a customary workstation. Thin clients began picking up pertinence with the selection of Software as a Service (SaaS).

The virtualization layer lies between the hardware and OS, and is implemented by a Virtual Machine Monitor (VMM). The VMM takes control over the resource multiplexing and deals with the portion of physical resources to the VMs. There are two routes in which a VMM can take an interest in power management.

1. **VMM can act as a power-aware OS**: monitor the general system performance and fittingly apply DVFS or any DCD procedures to the system segments.

2. **A VMM can influence the power management strategies connected by the guests OSes utilizing the application-level information, and map power management orders issued by the OSes of various VMs on real changes in the hardware power state, or enforce system-aware power constrains in an organized way.**

### 1.11 MOTIVATION

Mobile devices are resource constrained as far as storage capacity, battery life, network bandwidth and processor execution. There are circumstances in which a computation work surpasses the ability of a computing device. For instance, the portable client may need to execute an application in a shorter period than that of a mobile device. On the other hand, running a computation escalated application unsatisfactorily drains the
battery of the mobile gadget. To conquer these restrictions, there is a solution known as Computation Offloading known as Surrogate Computing and Cyber-Foraging (Sharifi et al., 2012; Kumar et al., 2013). Computation offloading relocates computation jobs from a mobile device to all the more powerful remote computing resources. These jobs are executed remotely boundless and the executed results are sent to the mobile device. Figure 1.7 portrays the procedure of computation offloading: step 1) the cloud customer starts offloading of a job to a cloud resource by sending the input information along with the program code, step 2) the cloud resource executes the job and in step 3) the cloud sends the output information through a communication network to the mobile device.

Computation offloading won’t lessen energy under all conditions. Therefore, we should decide under which conditions computation offloading is helpful to reduce energy consumption for mobile applications. Further, it is imperative to recognize those particular applications that advantage from computation offloading. Mobile users need to settle on a choice whether to offload a computational job and a choice of where to offload it. Nonetheless, it is hard to have an immediate status of the computation offloading framework since network conditions change often (e.g. queuing delays) and computation delays differ because of evolving workloads. The vulnerability of network conditions is intensified for remote systems where nodes are always moving and have continuous disconnections brought about by topology changes. This description work was supported by the USA Army Research Laboratory (ARL) (Sookoor et al., 2013) through Stanford University. Officers in conflict zone operations have one kind of necessity that makes computation offloading which is much additionally difficult. The
arena requires communication over an unreliable mobile ad-hoc network that leads to more separations and route changes contrasted with non-mobile systems.

Computation Offloading choices are made with an assessment of the accompanying choice criteria namely job parameters, computing resources parameters and communication network parameters. The job parameters include the job size which is the applications size that will get executed either on the mobile device or a cloud resource that incorporate the data that will be prepared by the application and the output information which are delivered from the computation. The computing resource parameters are the measurements that decide the status of the computing elements namely CPU speed, memory limit, storage limit, and current workload. The network communication parameters are the ones that demonstrate the status of the systems networking conditions. They include namely available bandwidth, congestion, packet loss rate, connection quality, and a number of hops to achieve an asset. Nonetheless, since these parameters are continually changing after some time, mobile devices cannot have an immediate precise measure. Rather, evaluated data is utilized to make offloading choices. That is the reason, we have found the chance to concentrate on the effect that mix-ups in the evaluations of these parameters which have the nature of the computation offloading choices. It is seen how precise estimation must be used as sound judgment. The inquiries that need to be responded in this research are:

1. When does offloading reduce the energy of mobile device?
2. Which applications advantage from offloading?
3. How networks delay estimation fault impact computation offloading choices when there is more than one offload target?

1.12 OBJECTIVE

The objectives of this research are:

1. To propose an architecture based methodology to extend the energy of mobile devices.
2. To propose a simulation based methodology to save energy of mobile devices.
3. To propose a software based methodology to improve battery life of Android mobile devices.

1.13 ORGANIZATION OF THE THESIS

The thesis is organized into six chapters with a definite focus as listed:
Chapter 2 briefly describes a survey on extending the energy of mobile devices using various methods.

Chapter 3 describes an architecture based methodology to extend the energy of mobile devices, Virtual Network Computing (VNC) to offload computation from mobile device to cloud, usage of Amazon Web Services (AWS). This chapter concludes with the performance analysis of the proposed approach.

Chapter 4 describes a simulation based methodology to save energy of mobile devices using CloudSim. Offloading and evaluation of performance are done using CloudSim simulator. This chapter concludes with the performance analysis of the proposed approach.

Chapter 5 describes the software based methodology to improve battery life of Android mobile devices. Comparison of battery levels with/without the application.

Finally, Chapter 6 ends with conclusions and future work of the thesis and also summarizes the discussed contributions.